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ABSTRACT

This study examined views of the human relationship with the natural world and understandings about the nature of science (NOS) held by preservice elementary teachers in the context of Taiwan. The participants included 54 third-year students enrolled in the departments of science education and mathematics education at a teacher college. Data were gathered by two open-ended questionnaires with follow-up interviews. An anthropocentric-moderate continuum emerged to describe participants' views of humanity's relationship with nature. Participants with informed NOS conceptions were more likely to emphasize harmony with Nature, recognize the limitations of scientific knowledge, and accept the idea that science involves subjective and cultural components. On the other hand, participants who provided a pragmatic perspective of Nature seemed to possess narrow views about the scientific enterprises by describing science as close to technology and as a mathematical benefit. The results in this study depict a group of nonwestern preservice teachers' worldviews and reveal the interplay between their sociocultural beliefs and NOS conceptions. People with different worldviews may have differing views about science. The study calls for the consideration of incorporating sociocultural perspectives in science instruction and the need for introducing contemporary conceptions of the NOS to science learners. (Author)

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TAIWANESE PRESERVICE TEACHERS' CONCEPTIONS OF NATURE AND THE NATURE OF SCIENCE

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Taiwanese Preservice Teachers' Conceptions of Nature and the Nature of Science

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Abstract

This study examined views of the human relationship with the natural world and understandings about the nature of science (NOS) held by preservice elementary teachers in the context of Taiwan. The participants included 54 third-year students enrolled in the departments of science education and mathematics education at a teachers college. Data were gathered by two open-ended questionnaires with follow-up interviews. An anthropocentric-moderate continuum emerged to describe participants' views of humanity's relationship with Nature. Participants with informed NOS conceptions were more likely to emphasize harmony with Nature, recognize the limitations of scientific knowledge, and accept the idea that science involves subjective and cultural components. On the other hand, participants who provided a pragmatic perspective of Nature seemed to possess narrow views about the scientific enterprises by describing science as close to technology and as a materialistic benefit. The results in this study depict a group of nonwestern preservice teachers' worldviews and reveal the interplay between their sociocultural beliefs and NOS conceptions. People with different worldviews may have differing views about science. The study calls for the consideration of incorporating sociocultural perspectives in science instruction and the need for introducing contemporary conceptions of the NOS to science learners.

Introduction

In recent decades, the science education community has recognized the problem of exclusively emphasizing the acquisition of scientific concepts in science learning, and has come to advocate a shift toward helping students understand the structure of scientific knowledge and the processes of scientific inquiry (American Association for the Advancement of Science [AAAS], 1990; Hodson, 1993; Millar & Osborne, 1998; National Research Council [NRC], 1996). Science educators in various countries, consequently, advocate the need for educational practice that focuses on understanding the nature of science (BouJaoude, 1996; Kumano, 1998; Ogunniyi, 1982).

The nature of science (NOS), also known as "science as a way of knowing," refers to the values and assumptions inherent to scientific knowledge (Lederman, 1992). It is generally believed that teaching students about NOS could help them learn science content (Songer & Linn, 1991), enhance their interest in science (McComas, Almazroa, & Clough, 1998), and most importantly, facilitate students' informed judgments and decisions about scientific and technological issues (Driver, Leach, Millar, & Scott, 1996; Smith & Scharmann, 1999). Therefore, in order to prepare scientifically literate students who can function in an increasingly scientific and technological society, the NOS needs to be presented as one of the most important objectives of science curricula (AAAS, 1990; BouJaoude & Abd-El-Khalick, 1995; Kimball, 1967; Lederman, 1992).

The role that sociocultural factors play in science teaching and learning has been studied for decades. Some of these studies (e.g., Allen & Crawley, 1998; Jegede & Okebukola, 1991; Kawagley, Norris-Tull, & Norris-Tull, 1998; Ogunniyi, 1982) are especially concerned with the difficulties of teaching science to students whose worldviews conflict with the western scientific worldview. Two major conflicts exist between traditional worldviews and the worldview conveyed by school science identified by Ogawa (1986) as one's "view of man and nature" and "way of thinking." That is, in some traditional or nonwestern cultures, people may not see the natural world as an object for investigation or of exploitation for human benefit. Such conflicts may influence students' thinking about how science works, which, in turn, prevent them from being scientifically literate. In fact, some research results (e.g. Allen & Crawley, 1998; George, 1999; Waldrip & Taylor, 1999; Zimmerman & Gilbert, 1998) have shown that traditional

worldviews negatively affect science learning and views about science, especially when science is presented in a conventional positivist fashion.

Worldview research, as advocated by Cobern (1991), provides explicit assumptions and a feasible methodology to further investigate the aforementioned issue. A worldview is a collection of values and beliefs, including its epistemological and ontological underpinnings, which forms the frame of reference for a group of people to make sense of the world (Kawagley, Norris-Tull, & Norris-Tull, 1998). As such, worldview research focusing attention on learners' cultural contexts may well inform educators the issues regarding the conceptualization of science and the public image about science (Cobern, 1991). Several studies in this field (e.g. Haider, 1999; Ogunniyi, et al., 1995; Shumba, 1999) have inferred a relationship between worldviews and conceptions of NOS. For example, Ogunniyi, et al. (1995) and Shumba (1999) argued that teachers who held more "traditional" worldviews were more inclined to have "inaccurate" conceptions of the nature of science. On the other hand, Haidar (1999) implied that teachers' informed views about the tentative nature of scientific knowledge were derived from their religious worldview. However, none of these studies examined people's nature of science views and worldviews concurrently. The relationship between nature of science conceptions and worldviews has remained implicit.

Purpose of the Study

A fundamental question guiding this investigation is, "do people with different cultural backgrounds have different views of science?" This study was conducted in attempts to see whether people's cultural views of world (worldviews) are related to their interpretations of what science is. The term "worldview" often refers to a broad meaning. In this investigation, taken into consideration the conflict identified by Ogawa as discussed previously, the focus of the worldview assessment was on people's views of human relationship to the natural world. The target subjects consisted of a group of preservice teachers, because it is assumed that their sociocultural values might affect how they implement the curriculum.

The second focus of the study was on assessing these preservice teachers' conceptions of the NOS. Current views of science bring about a more sociological

interpretation of scientific knowledge, in which science is described as an integral part of culture with emphasis on tentativeness, subjectivity, and social and cultural embeddedness. Exploring culturally specific values about science by means of an open-ended approach will generate more productive references about how to integrate contemporary NOS instructions in science teacher education programs successfully.

This study aimed to describe preservice teachers' conceptions of the NOS, and worldviews that represent their culturally dependent beliefs about the world, in the context of Taiwan. The additional intent of analysis was to empirically test whether there is a relationship between a person's worldview presupposition and his epistemological views of science.

Instruments

Two open-ended questionnaires and corresponding interviews were conducted to collect data on participant's views of Nature and conceptions of NOS. The first questionnaire (called Worldview questionnaire) contained five items to elicit responses on how and why humans acquire knowledge about the natural world and ideas of what relationship human beings should establish with Nature. The question items were adapted from the interview protocol of Cobern's study (1999) and critically reviewed by a panel of experts in the field of worldview research. The questionnaire was also pilot-tested with 10 elementary teachers to check its validity. Questions are listed in Appendix A.

The NOS questionnaire consisting of nine open-ended items aimed to assess seven NOS aspects: empirical basis, tentativeness, subjectivity, creativity and imagination, social and cultural embeddedness, differences between observation and inference, and functions of scientific theories and laws. Seven of the items were adapted from questionnaires developed by Lederman and O'Malley (1990) and Abd-El-Khalick et al. (1998). Two additional questions (see Appendix B, item #8 and #9) were designed to specify the characteristics of Chinese culture and aimed to explore respondents' views on the development of scientific knowledge in relation to cultural embeddedness. The development of question #8 was inspired by current debates in Chinese and Taiwanese society regarding the scientific legitimation of Chinese medicine (Chi, 1994). Question #9 was meant to assess respondents' beliefs about the validity of scientific claims made

by scientists of different ages, in attempts to study whether they realize that empirical evidence is essential to making scientific arguments. The content and face validity of the question items had been established in previous studies (e.g. Abd-El-Khalick, et al., 1998; Lederman & O'Malley, 1990; Liu & Lederman, 2001). Both questionnaires were translated to Chinese and the accuracy of translation was checked by back translation.

Participants

A total of 54 students enrolled in the third year of the elementary teacher preparation program at a teachers college voluntarily participated in this study. Of them 25 students were (18 male and 7 female) from science education department and 29 (12 male and 17 female) from mathematics education. Science content and methods courses are required only for the students enrolled in these two departments. At the time of this investigation, the participants had taken 12 to 20 credits of required science contents courses and were taking science methods/practicum courses. Before enrolled in the teacher education program, the majority of the participants had written a matriculation examination with physics, chemistry, and/or biology as required subjects. Three students had chosen test subjects not only with sciences but also including literature and social study. However, all of them selected mathematics and science as their major while studying in high school. The participants' ages ranged between 20 and 27, with a median of 21 years. Twenty-one students (39%) professed to have religious beliefs.

Data Collection

Data collection was conducted in two phases (Figure 1). In the first phase, the Worldview and biographical questionnaires were administered to the participants. After an initial analysis of their written responses, 14 students (accounting for approximate 25% of subjects who completed the Worldview questionnaire) were purposefully selected for follow-up interview according to their varying answers to each question and their differing background variables (i.e. major, gender, and religion).

Figure 1

All the participants were then asked to complete the NOS questionnaire after all worldview data were gathered. This procedure is to avoid leading participants' responses toward scientific concepts while assessing their conceptions of Nature. At this stage of data collection, 11 of the participants withdrew from the study mostly because of their unwillingness to sacrifice their spare time amidst tight schedules and examinations. Fortunately, the 14 selected interviewees all remained in the study and were interviewed again for their NOS views.

During the interviews, participants were asked to elaborate on their written responses and to clarify some key terms that were used to express their ideas. Their lines of thoughts on issues raised in both questionnaires were also pursued. Therefore, the follow-up interviews not only were used to establish the validity of the questionnaires but also functioned to categorize participants' responses. Written responses to the two questionnaires and corresponding interview transcripts were independently analyzed to generate separate profiles of participants' views. A comparison of profiles indicated that participants' written responses were generally congruent with those they expressed in the follow-up interviews.

Conceptions of Nature

Responses to the worldview items were analyzed as a whole, but the focus of analyses was initially on three dimensions. One was the awareness of Self as distinct from Nature. In this regard, participants' views about how and why humans acquire knowledge about Nature were examined. The second dimension was participants' descriptions of Nature. Specific attention was paid to understand the thoughts conveyed by the terms participants used to describe Nature. These analyses provided an overview of participants' perceptions of the human role in Nature that led to study the third dimension regarding the relationship of human beings to Nature.

Perception of Human Role

Seven categories emerged from the responses regarding how and why people study Nature: Humans are able to "accumulate experiences" and "develop science

(technology);" humans "need natural resources for survival" and are "practical," "dominant," "with limited ability," and "uncertain about reality." Responses from one participant could be placed in one or more categories.

Twenty-one participants whose responses fell into the category of "accumulate experiences" tended to limit human knowledge about the natural world to sense experiences and asserted that "we can learn about only the things that are closely linked with our life." Eleven responses were grouped in a relevant but distinct category identified by the phrase "developing science or technology to study." These students voluntarily mentioned that the scientific method(s) and instruments are to be used to study Nature. The third and fourth categories both were derived from the comments concerning human needs. Eight students indicated that human beings have a need to use natural resources for life. Eight other participants gave responses unlike those in the "need for survival" category, considering human beings to be practical or utilitarian. They applied the phrase "gain profits from Nature" in their responses, implying that they believe human beings utilize Nature to gain material benefits.

Four of the participants argued that humankind are dominant species and have unlimited potential and therefore is superior to other organisms. In contrary to this view, 14 participants demonstrated the view that humans have a "limited ability" to uncover Nature. They considered that even with advanced technology and profound knowledge, humans will never be able to know all about Nature. Additionally, 10 respondents further stressed the uncertain nature of human knowledge and believed that we humans have no way to confirm that what we know is true because we are limited in space and time.

Descriptions about Nature.

Participants' descriptions of the natural world fall under seven categories, including "created by God," "understandable," "full of resources," "in danger," "changeable," "powerful," and "living."

Only one participant regarded Nature in a thoroughly religious view, "created by God," and constantly referred the ideas to the creationist concepts. This student also believed that human beings are created to rule over things in the natural world. Seven responses were coded into the category of "understandable" with the view that things in

the natural world can be mostly known by human beings. Eleven of the participants described economic and aesthetic functions of the natural resources and intensely embraced the ideas of sustainable natural resource management. Five other participants ascribed to a conservationist perspective that depicted Nature as endangered entity. They especially expressed concerns on several environmental issues, such as pollution, landscape destruction, decrease of forests, and the endangerment of species.

Sixteen participants used terms similar to "changeable" to represent the idea that things in Nature are changing all the time. Of them, many had discussed the limitation and uncertainty of human knowledge to study things in the natural world. The "powerful" category included 15 responses expressing the effects of natural disasters on humans and the power of Nature that humans cannot resist. Many of these participants used an expression that could be literally translated to the sentence "Nature will fight back after being beaten off." The following written response is typical:

> Nature has its own order. Humans may be able to change Nature, but Nature will change to a different status to keep its *order* [Italic added]. For example, a few years ago, CFCs have been used as perfect solvents but turned out to be killers of our environment. We are now eating our own bitter fruit.

It is noted that the term "order" referring to the laws of nature often occurred in the participants' descriptions. However, the Chinese notion of order is somewhat different from the use of order or orderly in English. It does not necessarily refer to what is discoverable by human beings. Rather, it is more close to the meaning of dynamic balance that exists in Nature and between humans and Nature. The category of "living" consequently emerged from the responses viewing Nature as a living entity. Five participants described Nature as if it has a consciousness and is subject to the cycle of life. To these individuals, Nature is not something that can be controlled; it controls itself. The above analyses of participants' perceptions of Self and Nature have formed a picture of how they view the relationship between humans and Nature.

Views of the Human-Nature Relationship

The item #4, "what kind of relationship, in your opinion, should humans establish with Nature?" and item #5, "Do you agree or disagree with the statement – 'Man can

conquer Nature'?" were used in combination to discover participants' opinions about the interactions between humans and the natural world. Data elicited from these two items, also triangulated by responses to the other worldview questions, were analyzed to generate categorization for the Relationship dimension. Four categories were formed accordingly. The categories are presented as verbs because the researchers have analyzed the data in a way of finding words to fill in the sentence – "Humans should _____ (with) Nature."

The first category consisted of eight participants' responses with a view that human beings should "protect" Nature. They suggested that people could exploit the natural resources to improve life, but must also use the resources wisely and take the responsibility to protect Nature from being destroyed and polluted. To these participants, Nature seems to be an object that humans must utilize, study, and protect. In interview, one female participant stated that:

> Nature provides many things for the necessity of our survival, but Nature also needs our protection. I draw the relationship between humans and Nature like this: Man↔Nature. They both have interactions. When our earth encounters crises, like the event that happened in the movie *Armageddon*, I think we need to take the responsibility or at least have the obligation to protect it. I agree that humans have the power to conquer Nature. We can invent some useful instruments to do many things, such as to cave a mountain. To conquer Nature is to improve our lives.

Responses in the second category showed a view distinct from those in the "protect" category. Five participants advocated that humans should "obey" Nature and follow the order (laws) of the natural world. They emphasized that Nature may be explored and studied but human knowledge can only help us explain what can be seen in the present time. One participant who had taken psychology as dual major discussed his view of the natural world as follow:

> Nature is infinite. Since the development of science, our knowledge has been increased quantitatively and objectively. However, there are too many facets of the natural phenomena. The probabilities of their occurrence and the odds of being found by humans, adding all kinds of other factors, thus become infinite. As to what things in Nature can be understood, I think it depends on whether we have noticed them or not. People use a developed schema [he borrowed a term from psychology], which is like a set of values or concepts to study Nature. In order to survive, humans need a proper environment. Nature

provides us with a living environment with the aspects of time and space. We should follow the order of Nature unless we do not need this environment.

The rest of 37 participants had used the terms similar to "coexistence" to address the mutuality between humans and Nature. They seemed to emphasize harmony with Nature. However, a closer examination of the data revealed that some participants addressed the harmony relationship with a moderate attitude, while some discussed their point of views through a pragmatist perspective. Twelve students with a moderate attitude said that humans cannot be independent from the natural world and are not the possessors of Nature. They believed that humans can survive only if Nature is in a good condition. Almost none of them mentioned human dominance or the resource views of the natural world. Most had submitted comments about the limited ability and uncertainty of human knowledge. These responses were thus assigned the "Coexist - Moderate" category.

For the remaining 25 participants who had also noted the coexistence relationship, the pragmatist views about the natural world and human society were more likely to occur in their responses. Those participants tended to emphasize the importance of conservation and argued that Nature and humans should not defeat each other. In other words, they believed that the relationship between humans and Nature is like a friendship: giving benefits but not fighting against each other. These responses were grouped into the "Coexist-Pragmatist" category. It is noteworthy that the views under this category as elicited by the questionnaire were diverse to some extent and not as consistent as those in the other categories. However, the concepts of relationship of these 25 participants were generally considered as human-centered as those in the "protect" category.

An anthropocentric-moderate continuum thus emerges. Figure 2 was constructed as an attempt to visually summarize the analyses of the participants' views about humans' relationship with Nature. At the anthropocentric end appear people who hold that human beings have a dominant role in Nature and who describe the resource view of the natural world. At the moderate extreme are people who accept ideas about the limitations and uncertainty of human knowledge and who emphasize the power and unpredictability of Nature. Besides those typical responses located on two ends, most responses essentially distribute in the middle of the continuum. In general, participants' views classified into the "Protect" and "Coexist-Pragmatic" categories were considered to be close to the

anthropocentric side, while the "Obey" and "Coexist- Moderate" categories were on the moderate side. Overall, the results showed that the majority of the participants (61%) provided a human-centered or applied perspective, while 24% held a more moderate perspective in discussing the relationship between human beings and the natural world.

Figure 2

Conceptions of the Nature of Science

This section reports the profiles of participants' NOS conceptions with regard to the seven target aspects as defined previously. Responses to the two additional questions, which were concerned with the development of scientific knowledge in relation to Chinese cultural characteristics, were analyzed to verify the consistency of participants' views on the empirical aspect of NOS, and to examine their beliefs about authoritarianism under the context of scientific research. During the analysis, participants' views were constantly compared with the contemporary conceptions of NOS. In addition to generally classifying participants' responses as "informed" and "naïve" views, several categories were generated to express the features of their views for each aspect of NOS.

Table 1 presents the major categories that emerged from participants' views on each aspect of the NOS and the percentages of responses under the categories. This summary provides an overview of participants' understandings of the NOS.

Table 1

The majority of participants (87%) did not demonstrate adequate understandings about the empirical basis in the development of scientific knowledge. A few of them viewed science as equivalent to technology. The others believed that scientific knowledge should be proven true based on objective observations or experimental evidence. The

notion of experimental orientation in science was apparent in participants' discussions about what can be called scientific. Regardless of different medical treatment preferences, the majority of participants (63%) attributed Chinese medicine with the lack of experimental evidence. In addition, the scientific method, a step-by-step procedure used for scientific investigations, was manifested in many participants' responses concerning the definition of science (as hypothesis testing), creativity in scientific investigation, and the relationship between scientific theories and laws. Only 12% of participants explicitly noted that science is a human endeavor to explain the world and its phenomena. Similarly, while comparing Chinese and Western medicines, only six students (14%) recognized the philosophical and cultural differences inherent to the two medical knowledge systems.

Out of 43 students who returned the NOS questionnaire, 17 (40%) demonstrated adequate understandings of the distinction between observation and inference. They noted that the structure of the atom was determined through the analyses of indirect evidence and were able to identify the atomic structure as a model that could provide enough information and explanations for observations of some phenomena at the present time. Two of these participants were in favor of the idea of uncertainty while discussing the issue of how the structure of an atom is formulated. They indeed had embraced such an idea in their views of the human-Nature relationship. Still, the majority of the participants tended to believe that the atomic model has been proven or that knowledge of the atomic structure should not be questioned. Two students mistakenly stated that scientists can actually see an atom through microscopes.

All of the participants indicated that theories do change. However, the majority of them (77%) ascribed theory change solely to new information and technologies. Many also believed that theories are tentative due to insufficient evidence for proving their validity. Only 23% of the participants stated that theories change either with different ways of looking at existing evidence or when anomalous data are found. The analysis of participants' responses regarding the explanatory function of theories showed that 42% of them acknowledged that scientific theories are the best explanations of natural phenomena at the present time.

All of the respondents held naïve views on the relationship between scientific theories and laws. They generally believed that scientific laws can be proven true through

repeated testing. Also, they consider scientific theories to be tentative antecedents to scientific laws. Such concepts conformed to the belief that a hierarchical relationship exists between scientific theories and laws. Textbook analyses indicated that the participants' misconceptions of scientific laws and theories were the result of their secondary science education.

More participants provided informed views on the subjective and socio-culturally embedded nature of scientific knowledge; each accounted for 37%. These students were able to identify that scientists' prior knowledge, theoretical presuppositions, or personal beliefs might affect their interpretations of the data. Those (61%) who held naïve views on the subjective nature of science were more likely to attribute the cosmology controversy to the scarcity of evidence, even though they claimed that scientists have different viewpoints or ways of analyzing data. While discussing social and cultural embeddedness in science, participants who held more informed views either indicated science as being value-embedded from a pragmatic perspective, or used historical episodes and socio-scientific issues to address the relationship between science and societal expectations. The other participants (60%), on the contrary, viewed scientific knowledge as universal and failed to recognize that different belief systems could influence the use of scientific knowledge and the way scientific investigations are conducted.

Almost all participants indicated that creativity and imagination are needed in the development of scientific knowledge. However, participants put different emphases on the stages of investigation. About 40% of participants assigned creativity and imagination only to the planning stage. About 19% emphasized the use of creativity in generating ideas and scrutinizing inconsistent results, and indicated that data should be collected as objectively as possible. The other 28% of participants believed that imagination and creativity permeate all stages of scientific investigation. Yet, only six of them (14%) were able to describe creativity and imagination in terms of the invention of explanations. Another 9% of the participants particularly emphasized the use of creativity and imagination in the data interpretation stage, where scientists need inspiration for generating inferences and explanations from the data.

When stressing the importance of creativity and imagination, many participants further emphasized the value of experience or knowledge for scientists. About 28% of preservice teachers in this study tended to accept elder scientists' arguments on an environmental issue. They considered accumulation of experiences (knowledge) to be more important than creativity. On the other hand, 12% of participants were swayed more by creativity and chose younger scientists' ideas. These participants viewed experience and creativity as opposite attributions for scientists. However, about 44% of participants showed a shift away from authoritarianism. These students critically asked for a scientific conclusion that has valid evidence and fits into their premises or values.

An examination of individual understandings of NOS aspects showed that only five participants held adequate understandings of at least four aspects of the NOS. Nine preservice teachers in this study provided naïve views on all aspects of NOS.

Relationship Between Views of Nature and the NOS

An additional attempt of the present study was to explore any patterns existing in participants' responses to the worldview and NOS questionnaire. Statistical examination of the data, using the Chi-square test, was initially performed to seek relationships within categories for the entire sample. Only one trend was revealed that 11 out of 18 participants who noted the limited and uncertain nature of human knowledge expressed adequate views regarding the inferential aspect of science ($p = .02$). Systematic comparisons were then conducted by looking at the worldviews of participants who held better NOS understandings and who held naïve views on all NOS aspects. Analyses of the selected interviewees' narratives further provide insight into individual variations in terms of their NOS conceptions and worldviews.

Statistical evidence indicated that participants who held a moderate view of the human-nature relationship were more likely to have better NOS understandings ($p = .02$). Examination of interview data showed that four of the interviewees who held adequate views on at least four NOS aspects had subscribed to an indeterminist perspective on human knowledge about the natural world and integrated this concept into their discussions regarding the tentativeness, subjectivity, and creativity components in science.

Henry (pseudonym), a science education major, was a particular case who was chosen for interview because he emphasized a harmony relationship between humans and Nature. By comparing his responses to both questionnaires, the researchers found that Henry's knowledge about the tentative nature of science and the distinction between observation and inference was previously shown in his discussions of how humans study about Nature. He claimed that "Scientific laws are developed in an attempt to describe the orders in the natural world, yet they usually function under ideal conditions, where ideal is not the reality" (NOS interview). In the worldview interview, he had also stated that

> By the time we are able to break things apart, we will find that what we have known as truth is not true at all. We try to find order in Nature and explain it in an ideal situation. But the ideal is not the fact. What we have found is not the natural order but only the human constructed reality. We are using those constructs and laws to explain the natural world and we believe that the world follows the orders that we have observed and explained.

Henry demonstrated informed views on most NOS aspects but explicitly showed a reluctance to choose science related subjects as his graduate major. His beliefs about the scientific enterprise seemed to be that science has conventionally been depicted as part of the human attempt to control and study the world – a view that does not fit with his sociological perspective in interpreting science. He constantly critiqued the myth of science and the reductionism in interpreting natural phenomena.

Jason, another interviewed participant, also held comprehensive understandings on all aspects of the NOS except the relationship between scientific theories and laws. He indicated the degree of indeterminateness within Nature by discussing the object/subject interaction and reconciled this view with his discussion of the inferential, creative, and subjective components in science.

On the contrary, participants who held naïve views on most NOS aspects participants tended to convey an anthropocentric perspective regarding humanity's relationship with Nature. These participants limited their descriptions of Nature to the resources it provides and offered pragmatist or uninterested comments on how humans know things about Nature. The three selected interviewees either described science as equivalent to technology (emphasizing its mere function of improving life) or considered scientific knowledge to be proven truth. It is also noted that these participants with naïve

NOS views were often not reflective enough to be able to comment on the ideas raised in the questionnaires. Their views of human knowledge about the natural world and epistemological understandings of science were dim, fluid, and fragmented.

Discussion

This study proposed an anthropocentric-moderate continuum to describe the variation of sociocultural beliefs regarding the human-Nature relationship held by a group of preservice elementary teachers. On the anthropocentric side, Nature is often described in terms of resources and necessity for humans, and human capability of protecting and managing the natural world is emphasized. Opposite to the anthropocentric view is a view defined identified as "Moderate," which asserts we humans should respect the existence of Nature. The relationship between Self and Other as harmony is the dominant concept in Chinese history, and it is still evident in people's beliefs about the relationship at the present time in Taiwan. Over two thirds of participants adopted terms with meanings similar to the English word harmony in order to express the human-Nature relationship. However, some advocated the harmony relationship between humans and Nature but at the same time deemed exploitation of Nature as necessary for human survival (e.g. Cheng, O'Leary, & Page, 1995; Cobern, 2000; Sodowsky, et al., 1994).

It cannot be overlooked that participants' conceptualizations of Nature has been influenced by their experiences of natural disasters that recently occurred in Taiwan. Vivid memories of the natural events (earthquakes and typhoons) led some participants to reflect upon how helpless and limited human abilities are in comparison to Nature. However, not all participants reached such conclusions. Several participants demonstrated a great deal of confidence in the human ability to overcome the challenges of their environment. The pragmatist view of Nature is apparent in their ideas about using natural resources. According to these analyses, the continuum with two extreme ends seems to be the better interpretive means to express people's conceptualizations of nature in the context of Taiwan. Apparently, the majority of responses are situated in the middle of the continuum, and sometimes fragmentary and changeable depending on the context.

Preservice teachers' conceptions of the NOS in the present study corresponded with a relatively extensive line of research indicating that both students and teachers' NOS

views are not consistent with contemporary conceptions of scientific endeavor (Duschl, 1990; Lederman, 1992). An overwhelming majority of participants (over 70%) held inadequate views of the empirical NOS, tentativeness of scientific knowledge, and creativity and imagination involved in scientific investigation. Moreover, almost all participants conveyed a hierarchical view of the relationship between scientific theories and laws.

None of the participants, however, believed that scientific theories *do not* change. The notion that everything changes with variations in time and space was manifest in many participants' responses. This even affected a few interviewed participants' conceptions of scientific laws to consent that scientific laws are subject to change as well. Such a finding seems to imply that participants were more likely than their western counterparts (Abd-El-Khalick, 2001; Brickhouse, at al., 2000) to adopt a relativist view of science. Yet, while further probing their lines of thought, it was found that a considerable majority of participants had limited knowledge about the development of those well-established theories and did not comprehensively understand the practices and processes inherent to the scientific enterprise. Furthermore, similar to other NOS research conducted in nonwestern contexts, the results of this study showed that some participants viewed science as close to technology (Akienhead & Otsuji, 2000) and as a materialistic benefit (to better life) (Aikenhead & Otsuji, 2000; BouJaoude, & Abd-El-Khalick, 1995; Cobern, 1989). This finding suggested that the public image of science in Taiwan is portrayed in a pragmatic way rather than with a theoretical focus.

The item regarding Western and Chinese medical knowledge was designed to examine participants' conceptions of what can be considered scientific. It was found that the majority of participants, regardless of their preferred type of medical care, deemed Chinese medicine to be a proto-science that is fundamentally testable but requires more investigation and experimental evidence. Consistent with the finding in Liu and Lederman's study (2001), Taiwanese students often identify scientific as something experimental. Furthermore, the present study found that participants equated "scientification" with "modernization." The majority of participants generally did not realize that there are profound differences between the approaches, theoretical underpinnings, and philosophies inherent to the development of these two medical

systems. Of course, it is not to be expected that anyone with little background in the history of medicine be able to clearly identify these differences. Participants' anticipation for scientific legitimation to make Chinese medicine more efficient generates concerns, however. The empiricist view appeared to have been very influential on participants' conceptions in this respect. Science instruction, following the empiricist (logical positivist) paradigm, depicted scientific inquiries as merely experimental confirmation and embraced the step-wise scientific method (Rudolph & Stewart, 1998; Shumba, 1999). Given such a view of science, it is not surprising to find that participants overlooked the social and cultural differences and counted on the universal scientific method to unveil Chinese medicine.

Relevant literature (e.g. Ogunniyi, et al., 1995; Shumba, 1999) suggested that teachers having more traditional worldviews were more likely to hold inadequate conceptions of the NOS. The so-called traditional worldviews are typically defined as spiritualism, authoritarianism, metaphysics, and harmony (nonmaterialism). If based on this definition, the results generated from the present investigation might not completely accord with Ogunniyi, et al. and Shumba's arguments. It was found in the present study that participants who held informed NOS understandings were more likely to emphasize harmony with Nature. This finding was further confirmed by analysis of interview data. The interviewed participants with better NOS conceptions seemed to reconcile the view of the limitedness and uncertainty of human knowledge about Nature with their interpretation of the scientific enterprise, especially regarding the tentativeness, subjectivity, and influential aspect of the NOS. On the contrary, those who held naïve NOS views were more likely to convey the materialistic views of Nature. Such a pattern between the views of the human-Nature relationship and NOS understandings may reflect on people's epistemological beliefs about knowledge. However, this relationship is by no means straightforward and causal. Just as the image of a continuum is intended to illustrate, a shadow zone always exists between the two easily distinguished positions at the extreme ends.

Implications

For Teaching and Teacher Education

A major shift of current emphasis in science curriculum development is toward ensuring familiarity with the structure of scientific knowledge and the processes of scientific inquiry (Hodson, 1993). The results of the present study, consistent with the findings in other western and nonwestern countries (e.g. Aikenhead & Otsuji, 2000; Haidar, 1999; Lederman, 1992), suggested that such a goal demands much more effort in order to achieve. Participants' views of science typically reflected the views that had been presented to them throughout the curriculum of their past education. It is still common for the school curriculum in Taiwan to present science as a body of absolute knowledge and to regard scientific discovery as the outcome of the correct application of a rigorous, objective, value-free, and powerful scientific method. This image of science will be continuously passed onto students if no specific and rigorous attempts are made to improve teachers' NOS understandings.

Science has long been introduced to nonwestern people in rational and mechanistic terms. For learners who, like this study's participants, could be considered "potential scientists" (Costa, 1995), this mechanistic worldview did not seem to completely dominate their thinking. According to the worldview data, some students held a holistic view of the world with a focus on personal experiences and humanism. While recognizing the conflicts between scientific worldview and the holistic view of humanity's relationship with Nature, they were more likely to consider the limitations of scientific knowledge and accept the idea that science is a human endeavor inevitably involving subjective and cultural components. These particular individuals adopted ecological and sociological perspectives for interpreting humanity's relationship with Nature and the epistemology of scientific knowledge. From the outcomes of these cases, it can be expected that such an understanding of the nature of science would be reinforced, as was advocated by many multicultural science educators (Cobern, 1991; Hodson, 1993; Stanley & Brickhouse, 1994), by involving learners in reflective thinking about the sociocultural influences of scientific and technological knowledge. In other words, science and its worldview should be related to wider societal and cultural issues.

Besides the positive outcome for NOS understandings as discussed above, the

findings also indicated that a number of participants emphasized the practical aspects of science, as well as the resource views of Nature. Such a pragmatist philosophy is not strange to Chinese people. According to ancient Chinese sages, such as Confucius, the accumulation of knowledge about the world is important for survival and for managing the relationship between humanity and the environment. Once science, along with technological advancement, presents people with an image of modernity and economic advantage, people applaud its pragmatic and materialist elements. Since the values of science and the goals of science education have been prudently reconsidered, as is reflected in Hodson's assertion that, "we *can* reorient our science and technology away from the reckless pursuit of economic growth toward more humanitarian ends and toward the solving of current environmental problems and the establishment of environmentally sustainable technological practices" (1993, p. 706). The pragmatic perspective of science and Nature provided by the participants should catch science educators' attention. Should we allow the notion that "science causes economic progress" to become the main focus of science education, while this causal link has been questioned (Drori, 1998)? This issue needs to be put on the board for Taiwanese science educators and policy makers to evaluate the nature of current science instructions and to rethink the goal of science education, especially while the country is under a major educational reform attempting to align it with international trends.

Another implication of this study for teacher education, especially in nonwestern cultures, is that the cultural aspects of science need to be conveyed to teachers. As science learners, some of these preservice teachers have experienced and recognized the "borders" between their own beliefs (worldviews) and the culture of school science. According to Aikenhead (1996), if a teacher is more aware of the differences between science culture and their own culture, he/she is enabled to act as a "cultural broker" to help students learn science in the classroom. As advocated by many reform documents (NRC, 1996) and researchers in the field of multicultural science education (Aikenhead, & Otsuji, 2000; Atwater & Riley, 1993; Lee, 1997), developing an understanding of the NOS is a prerequisite to teaching "science for all." Thus, the challenge to science teacher educators is to acknowledge potential cultural clashes in their science classrooms and science methods classes, as well as to help preservice and inservice teachers develop

culturally sensitive science instructions for their future practices. In reflecting upon the results of the present study, it seems that examining learners' presuppositions of humanity's relationship with Nature, for example, might serve as a reference for instructional materials regarding ecological conservation and for discourses about the cultural differences in viewing the world. Incorporating discussions about indigenous knowledge such as Chinese medicine, or historical episodes of the development of some scientific constructs with explicit instructions of the NOS (Akerson, Abd-El-Khalick, & Lederman, 2000) could also effectively raise teachers' awareness of cultural perspectives in science.

This study provided some insight into the worldviews and NOS conceptions of Taiwanese preservice elementary teachers. The findings showed that they held diverse views, some of which did not accord with the scientific worldview generally conveyed by Western culture. Results concerning the participants' cultural-dependent perspectives of science, which were elicited from their worldview responses, could offer valuable information for science teacher education. People with different worldviews may have differing views about science; such differences need to be acknowledged and incorporated into curriculum development and teacher education programs in order to meet the goal of science education in the country. Emphasis on teaching "science as inquiry" and describing "science as culture" is the major implication suggested by this study. Science educators should consider the possibility of incorporating sociocultural perspectives in science instruction and the need of introducing contemporary conceptions of the NOS to science learners.

For Future Research

The present study revealed patterns in participants' responses to the worldview and NOS questionnaires. For example, some participants showed flexibility in accepting the tentative nature of human knowledge about the nature of the world and science. However, such a pattern might be an artifact of the interviewed participants' idiosyncratic ideas rather than a reflection of a more general trend of thought for a larger population. It might be necessary to test the generalizability of this pattern with extended data from a larger population in future research. A series of questions might be designed with focuses on

assessing learners' epistemological beliefs about knowledge in general, and about scientific knowledge in particular, to ascertain the relationship.

Teachers' social and cultural values might affect their implementation of the curriculum. Furthermore, many researchers believed that NOS knowledge might play a vital role in directing teachers' instructional practices. Yet, the translation of teachers' NOS conceptions into practice, as seen in relevant studies (Abd-El-Khalick & Lederman, 2000; Lederman, 1999), may involve other factors. The findings in the present study revealed the interplay between the preservice teachers' sociocultural beliefs and their NOS conceptions. Research efforts should be extended to seek specific patterns existing in the interactions of NOS conceptions and worldviews. Such research would be useful for science teacher educators to identify what sociocultural factors influence science learners' views about science and their interpretations of NOS knowledge. Further research attention could be directed toward studying whether science teachers project their sociocultural interpretations of science into classroom discourses. If yes, how and to what extent do they incorporate such interpretations into their science teaching? Furthermore, if a certain view of science is identified as undesired or misrepresented, special efforts should be made to explore effective programs for informing teachers about the nature and practice of science.

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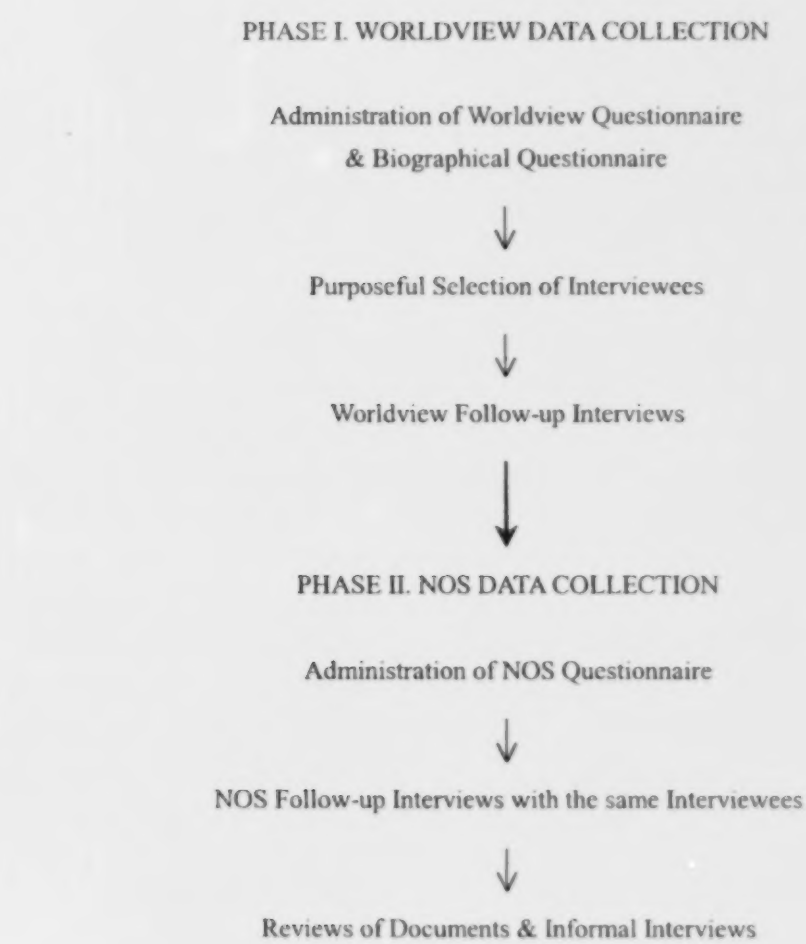
PHASE I. WORLDVIEW DATA COLLECTION
Administration of Worldview Questionnaire
& Biographical Questionnaire
Purposeful Selection of Interviewees
Worldview Follow-up Interviews
PHASE II. NOS DATA COLLECTION
Administration of NOS Questionnaire
NOS Follow-up Interviews with the same Interviewees
Reviews of Documents & Informal Interviews

Figure 1. Schematic of Data Collection Procedures

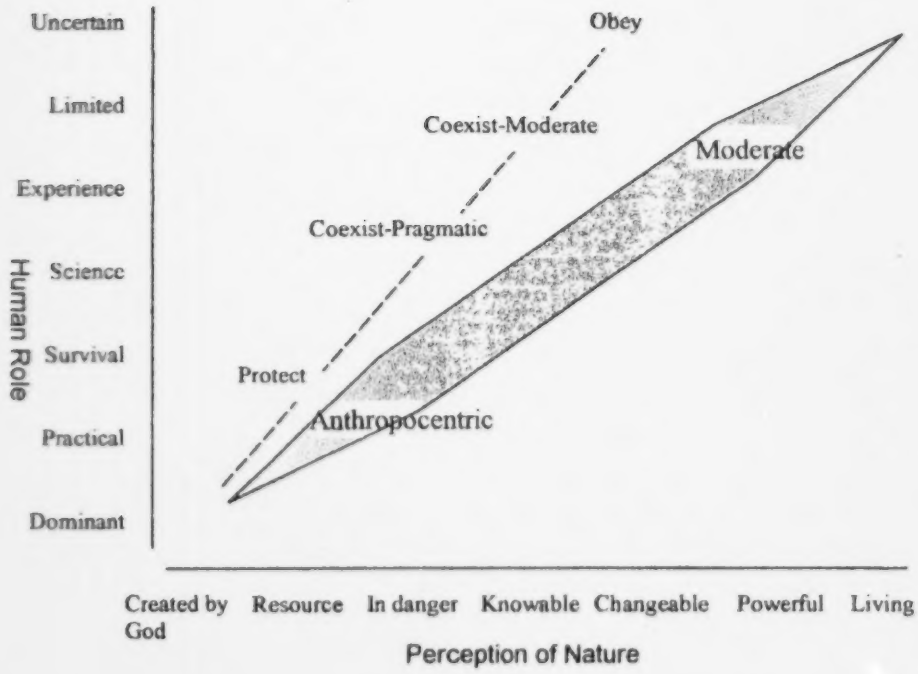

Figure 2: A Continuum of Participants' Views about Human Self and Nature

Table 1: Category and Frequency of Responses Regarding NOS Aspects

NOS Aspect	Code	Major Category	Frequency*
Empirical basis		Naïve	
	N.1	Science as technology	14%
	N.2	Science as a pursuit of truth	28%
	N.3	Empiricist view	39%
		Informed	
	I	Science as a human endeavor	12%
Inferential nature		Naïve	
	N.1	Scientists can see the atom	5%
	N.2	Atomic model is proven	28%
	N.3	Faith in scientists	16%
	N.4	No critique about textbook knowledge	7%
		Informed	
	I	Atomic structure is determined by indirect evidence	40%
Tentativeness		Naïve	
	N.1	Theories change solely with accumulation of information and advanced technology	23%
	N.2	Scientific theory is an idea	28%
	N.3	Everything changes	26%
		Informed	
	I	New ideas/anomalies cause change	23%
Scientific theories/ laws		Naïve	
	N.1	Inadequate definition for theories	12%
	N.2	Theory as unproven hypothesis	12%
	N.3	Explicitly express hierarchical relationship	19%
	N	Laws are more certain than theories	95%
Human creativity/ imagination		Naïve	
	N.1	Planning and design stage only	40%
	N.2	Design and interpretation stages	19%
	N.3	All stages, but limited to hypothesis testing	14%
		Informed	
	I.1	All stages	14%
	I.2	Emphasis on data interpretation stage	9%
Subjectivity		Naïve	
	N.1	Lack of powerful evidence	30%
	N.2	Need to reach consensus among scientists	12%
	N.3	Limitation of human ability	12%
	N.4	Scientists' egos behind the controversy	7%
		Informed	
	I	Subjective factors influence data interpretation	37%
Social/cultural influences		Naïve	
	N.1	Universal – scientific facts applied everywhere	30%
		Universal – global village	
	N.2	Accept both statements, but emphasize universal use	7%
	N.3	of scientific knowledge	23%
		Informed	
		Value embedded – pragmatic view	
	I.1	Value embedded – historical episodes	23%
	I.2		14%

*Percentages shown in the column do not necessarily add up to 100%.

Appendix A

WORLDVIEW QUESTIONNAIRE

The following questions are to ask your thinking about Nature.

1. When speaking of "Nature," what are the impressions that come to your mind?
2. Can human beings know all of the things about Nature? Why can or why cannot?
3. What sorts of things can humans know about Nature and how do these things become known?
4. What kind of relationship, in your opinion, should humans establish with Nature?
5. Do you agree or disagree with this statement - "Man can conquer Nature"? Please explain why you made that choice.

Appendix B

NATURE OF SCIENCE QUESTIONNAIRE

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g. religion, philosophy, or art)?
2. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, do you think scientists used to determine what an atom looks like?
3. Is there a difference between scientific theories and scientific laws? Give an example to illustrate your answer.
4. After scientists developed a scientific theory, does the theory ever change?
   - If you believe that scientific theories do not change, explain why with examples.
   - If you believe that scientific theories do changed:
     (a) Explain why theories change?
     (b) Explain why we bother to learn scientific theories.
5. Scientists perform investigations when trying to solve problems. Do scientists use their creativity and imagination during their investigations?
   - If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.
   - If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.
6. In the recent past, astronomers differed greatly in their predictions of the ultimate fate of the universe. Some astronomers believed that the universe is expanding while others believed that it is shrinking;

still others believed that the universe is in a static state without any expansion or shrinkage. How were these different conclusions possible if the astronomers were all looking at the same experiments and data?

7. Some claim that science is blended with the social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.
   - Which one do you believe? Explain why and defend your answer with example.
8. When you have a chronic disease, which kind of medical treatment would you choose to use, Chinese medicine or Western medicine? Describe your reason. In your view, is there a difference between knowledge verifying the effectiveness of Chinese medicine and that of Western medicine? Someone says, "Chinese medicine is not scientific." What is your comment on this statement?
9. An elder scientist and a younger scientist both engage in the same field of scientific research (e.g. environmental science) and their achievements have been recognized in the scientific community. However, they hold different views on an environmental issue. Whose view are you most likely to accept if you are required to take a stand? Explain your idea.

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